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GEOGRAPHIC INFORMATION SYSTEM APPLICATIONS TO PUBLIC WARNING SYSTEMS

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ABSTRACT

This paper describes the capabilities of a geographic information system (GIS), the Integrated Emergency Management Information System (IEMIS), for planning a siren-based public warning system. The Outdoor Sound Propagation Model (OSPM) in IEMIS models warning sirens in a given area and reports the results graphically as sound pressure level contours. As implemented in IEMIS, OSPM includes graphic functions for the preparation and display of input data, display of the model's results, and management of data files. These graphic functions enable public safety personnel to plan more effectively for warning of the public.

INTRODUCTION

The Outdoor Sound Propagation Model (OSPM) models public warning sirens in a given geographic area and reports sound pressure levels (SPLs) in dBA, dBC, and eight octave-band frequencies (63 Hz through 8 kHz) for a gridded set of points around the center of the area of interest. OSPM was prepared by International Energy Associates, Ltd., for the Federal Emergency Management Agency (FEMA), and is included in FEMA's Integrated Emergency Management Information System (IEMIS).

As implemented in IEMIS, OSPM includes graphic functions for the preparation and display of input data, display of the model's results, and management of data files. While some of the data manipulations are performed using text-based forms, all such forms can be accessed through a set of graphic menus.

OSPM is used by FEMA to evaluate configurations of sirens that are used to warn the public in the vicinity of nuclear power plants. Within FEMA, OSPM is the accepted model for such evaluations. The predominance of the model's application to nuclear power plant warning systems is historic, springing from the attention given to nuclear power safety after the Three Mile Island accident of 1979. However, there is nothing in OSPM that is inherently oriented toward nuclear power applications. The model may be equally well applied to warning systems for any other hazards.

CRITERIA FOR ACCEPTABILITY OF PUBLIC WARNING SYSTEMS

The graphic display features of the IEMIS implementation of OSPM render the model especially useful for evaluating the acceptability of a siren system with respect to Federal guidance. Federal criteria for evaluating siren systems to warn the public living around nuclear power plants specify that either:

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• The expected siren SPLs must generally exceed 70 dBC where the population exceeds 2,000 persons per square mile, and 60 dBC in other inhabited areas; or

• The expected siren SPLs must generally exceed the average measured summer daytime ambient SPLs by 10 dB (for geographical areas with fewer than 2,000 persons per square mile). [1-3]

The 10dB differential above daytime ambient SPLs is meant to provide a distinguishable signal inside of average residential construction under average conditions. Such a differential has been a basic objective of a wide range of civil defense systems. [2]

In addition to SPL criteria, Federal guidance stipulates map-based reporting of results for areas around nuclear power plants. Among the items to be depicted on maps are:

• Areas where the population density exceeds 2,000 persons per square mile;

• Unpopulated areas that are not covered by an alerting mechanism;

• Siren locations and identifiers; and

• SPL contours of 60 dBC, 70 dBC, or 10 dB above measured background levels, as appropriate, showing the geographical areas covered by a siren system. [1]

The implementation of OSPM in IEMIS directly supports map-based reporting of SPLs.

Federal policy also recognizes that sirens may be only a portion of a complete public warning system. Special individual cases, such as industrial areas, or facilities housing hearing-impaired residents, may require warning by means other than a generally distributed siren signal. The graphic display of OSPM results can provide planners with information that may be useful in identifying geographic areas that require means of warning other than sirens.

FUNCTIONAL AND OPERATIONAL CAPABILITIES OF OSPM IN IEMIS

Figure 1 shows the IEMIS top-level graphic menu for OSPM. Many of the functional capabilities reflected in the menu are significant for the planner of a public warning system.

The **CHANGE CASE/SITE** function enables the user to explore a variety of siren deployment strategies (up to 1,000 scenarios) for a given area; or, if a jurisdiction has several subareas of interest for public warning, to explore scenarios for each of those subareas separately. Once an initial scenario is defined, this function provides the bookkeeping necessary to quickly and easily make changes to that scenario.

The **DISPLAY BASE MAP** function is the initial entry point for displaying the deployment of sirens and the results of OSPM calculations against a map of the affected area. This function is shared in common with all of the map-based functions of IEMIS, enabling the user to view a variety of geographic features. Of particular interest in OSPM applications are the display of land/water boundaries and administrative or political boundaries, as a guide to what areas require coverage by a public warning system; the display of elevations, either as cell data or as calculated contours, helping the planner to visualize potential barriers to siren effectiveness, or alternatively, to visualize the most effective locations for siren placement; the display of population cell data, helping the planner to see areas where siren coverage is most needed, or other areas where alternative warning systems might be more beneficial; and the display of transportation networks (such as roads and airports), helping the planner to assess the feasibility of alternative warning systems, such as siren-equipped vehicles.

The **CONTOUR RESULTS** function enables the user to visualize the SPLs of a siren scenario by drawing line contours on a background map. The contours represent isopleths of SPLs at specific frequencies (ranging in octaves from 63 Hz to 8 kHz), or as measured in dBA or dBC. IEMIS allows the user to specify the contour values to be displayed. This function therefore provides a powerful tool for comparing the results of a siren scenario with the levels specified in Federal guidance (70 dBC, 60 dBC, or 10 dB above measured background levels). In combination with display of the

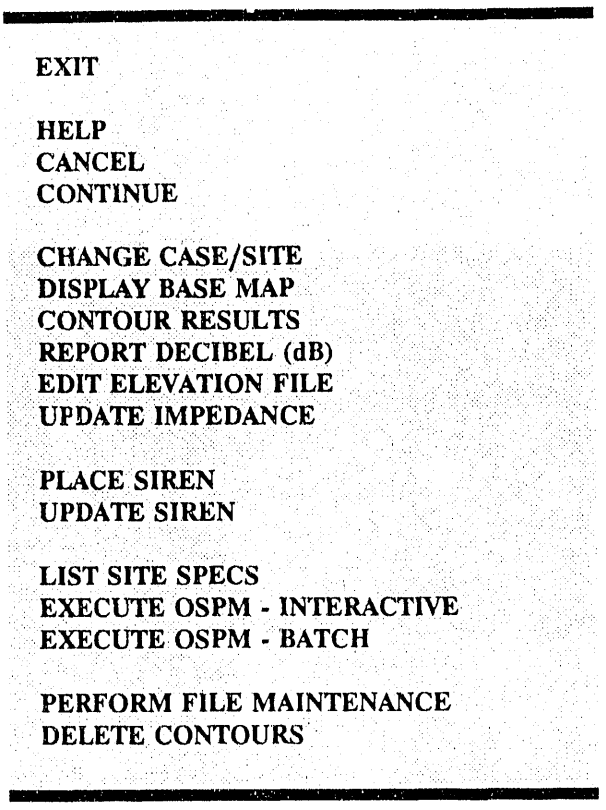

Figure 1. OSPM Top-Level Menu

background map and of population cell data, display of SPL contours allows the user to estimate how much land area and population, if any, lack adequate siren coverage.

The **REPORT DECIBEL (dB)** function provides a way to obtain a text report of SPLs calculated at a point selected by a graphic pick, as an adjunct to an overall display of SPL contours. Each report includes all eight of the octave bands and both dB measures calculated by OSPM.

The **EDIT ELEVATION FILE** function allows the user to review and modify the gridded elevation data used by OSPM. Most users will have little occasion to use this function once the initial site creation process is completed; however, the editing function may be useful to check for discrepancies in the elevation data (or perhaps if one lives near Mt. St. Helens).

The **UPDATE IMPEDANCE** function, like the editing of elevation data, allows the user to review and modify gridded data describing a site. In this case, however, the grid cells contain "impedance" values, indicating the acoustic "hardness" or "softness" of each cell. Again, these data will seldom change after the initial definition of a site; however, the function may be useful for reviewing the initial site data or for updating the impedance values if, for instance, a "soft" area becomes more heavily developed and predominantly paved. (For convenience, if this function is needed, a related menu gives the user the option of graphically defining an irregular boundary of cells all to be changed, rather than editing each cell individually.)

The **PLACE/DELETE SIREN** function enables the user to define or edit the configuration of a siren system in a given scenario. The graphic implementation of OSPM allows the user to place or delete sirens by picking the location of siren icons on a site map. The planner can use this function to experiment with several different types and placements of sirens in configuring a public warning system. Several options are available from a sub-menu (Figure 2) to facilitate this function:

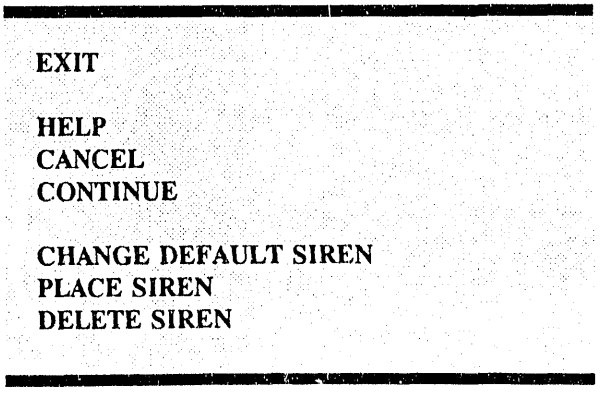

Figure 2. **PLACE SIREN** Sub-Menu

- The **Change Default Siren** option allows the user to define the type of siren that is to be added to a public warning system scenario. When exercising this option, the user can choose from a predefined list of the most commonly used siren types; or define a new siren type by specifying its name, its sound pressure values at 100 ft, and whether it is rotating or stationary.

- The **Place Siren** option allows the user to add a siren to the current scenario by picking its location on the site map and by specifying its mounting height on a form accessed from the graphic menu.

- The **Delete Siren** option allows the user to delete an existing siren from the current scenario by picking a point on or near the siren's icon on the site map. As a precaution, the graphic user interface confirms the intended deletion by blinking the picked icon and querying the user. The

same interface allows the user to delete one or all of multiple sirens that may be collocated on the map.

The **LIST SITE SPECS** function accesses a form for entering meteorological data for the scenario and for specifying the level of resolution of OSPM output. The planner can specify the predominant meteorological conditions for a geographic area, or a variety of meteorological data in different scenarios, to examine the effectiveness of a public warning system under different conditions. By changing the number and spacing of grid points for which OSPM calculates its results, the planner can tailor the level of detail of the output to the needs of a particular analysis.

Several menu functions (**EXECUTE OSPM - INTERACTIVE, EXECUTE OSPM - BATCH, HELP, CANCEL, CONTINUE,** and **EXIT**) are provided to facilitate the execution of OSPM and the management (cataloging and deletion) of scenario data files.

Finally, the **DELETE CONTOURS** function removes from the graphics display any existing SPL contours, while leaving the other map features intact. Thus, the planner can view sequentially the SPLs of different octave bands or measures of dB from the same scenario, yet can avoid visual clutter.

BENEFITS OF OSPM INTEGRATION INTO THE IEMIS GIS

In the past, public warning sirens had to be modeled individually and manually to determine the overall sound output levels at locations of interest. OSPM provides a way to model many sirens simultaneously; but, even with such a model, many analysts have had to rely on tabular outputs and to relate those outputs manually to the geography of an area. Now, with OSPM fully integrated into the IEMIS GIS, the planner of a public warning system can enjoy the advantages of a computer graphic display:

- Visualization of SPL contours enables the planner to easily see what areas lack coverage.

- Graphic picking of the output display enables the planner to easily obtain an estimate of results for any point of interest.

- Visualization of siren locations simultaneously with elevations and demographic data can make more intuitive the placement of sirens for greatest effectiveness.

- The ability to simultaneously display model results and population values enables the planner to determine how serious a lack of siren coverage may be for a given area and possibly to consider alternative means of warning the public. The display of additional geographic data, such as transportation networks and locations of special facilities, can provide insight into the feasibility of alternatives to sirens.

REFERENCES

1. Federal Emergency Management Agency, Guide for the Evaluation of Alert and Notification Systems for Nuclear Power Plants, FEMA-REP-10, November 1985.

2. U.S. Nuclear Regulatory Commission and Federal Emergency Management Agency, Criteria for Preparation and Evaluation of Radiological Emergency Response Plans and Preparedness in Support of Nuclear Power Plants, NUREG-0654/FEMA-REP-1, Rev. 1, November 1980.

3. Federal Emergency Management Agency, Outdoor Warning Systems Guide, CPG-1-17, March 1980.

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